Selected Chemical Analyses of Waters from the South Nahanni River Watershed, Northwest Territories

J.A. Babaluk, D.P. Tate, and J.D. Reist

Central and Arctic Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, MB R3T 2N6

2009

Canadian Data Report of
Fisheries and Aquatic Sciences 1215

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada

Canadian Data Report of Fisheries and Aquatic Sciences

Data reports provide a medium for filing and archiving data compilations where little or no analysis is included. Such compilations commonly will have been prepared in support of other journal publications or reports. The subject matter of the series reflects the broad interests and policies of Fisheries and Oceans Canada, namely, fisheries management, technology and development, ocean sciences, and aquatic environments relevant to Canada.

Data reports are not intended for general distribution and the contents must not be referred to in other publications without prior written clearance from the issuing establishment. The correct citation appears above the abstract of each report. Each report is abstracted in the data base *Aquatic Sciences and Fisheries Abstracts*.

Data reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page.

Numbers 1-25 in this series were issued as Fisheries and Marine Service Data Records. Numbers 26-160 were issued as Department of Fisheries and Environment, Fisheries and Marine Service Data Reports. The current series name was changed with report number 161.

Rapport statistique canadien des sciences halieutiques et aquatiques

Les rapports statistiques servent de base à la compilation des données de classement et d'archives pour lesquelles il y a peu ou point d'analyse. Cette compilation aura d'ordinaire été préparée pour appuyer d'autres publications ou rapports. Les sujets des rapports statistiques reflètent la vaste gamme des intérêts et politiques de Pêches et Océans Canada, notamment la gestion des pêches, la technologie et le développement, les sciences océaniques et l'environnement aquatique, au Canada.

Les rapports statistiques ne sont pas préparés pour une vaste distribution et leur contenu ne doit pas être mentionné dans une publication sans autorisation écrite préalable de l'établissement auteur. Le titre exact figure au haut du résumé de chaque rapport. Les rapports à l'industrie sont résumés dans la base de données *Résumés des sciences aquatiques et halieutiques*.

Les rapports statistiques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement d'origine dont le nom figure sur la couverture et la page du titre.

Les numéros 1 à 25 de cette série ont été publiés à titre de Records statistiques, Service des pêches et de la mer. Les numéros 26-160 ont été publiés à titre de Rapports statistiques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom de la série a été modifié à partir du numéro 161.

Canadian Data Report of

Fisheries and Aquatic Sciences 1215

2009

SELECTED CHEMICAL ANALYSES OF WATERS FROM THE SOUTH NAHANNI RIVER WATERSHED, NORTHWEST TERRITORIES

by

J.A. Babaluk, D.P. Tate[1], and J.D. Reist

Central and Arctic Region

Fisheries and Oceans Canada

501 University Crescent

Winnipeg, MB R3T 2N6

[1]Parks Canada, P.O. Box 348, Fort Simpson, NT, X0E 0N0

© Her Majesty the Queen in Right of Canada, 2009.

Cat. No. Fs 97-13/1215E ISSN 0706-6465

Correct citation for this publication is:

Babaluk, J.A., Tate, D.P., and Reist, J.D. 2009. Selected chemical analyses of waters from the South Nahanni River watershed, Northwest Territories. Can. Data Rep. Fish. Aquat. Sci. 1215: v + 19 p.

TABLE OF CONTENTS

	Page
ABSTRACT/RÉSUMÉ	v
INTRODUCTION	1
MATERIALS AND METHODS	1
Description of the study area	1
Water sampling and analysis	2
DATA PRESENTATION	3
ACKNOWLEDGMENTS	4
REFERENCES	4

LIST OF TABLES

Table		
1	Chemical analyses of surface water samples collected in 2005 from selected waters in the South Nahanni River watershed, Northwest Territories	6
2	Chemical analyses of surface water samples collected in 2005 from selected waters in the South Nahanni River watershed, Northwest Territories	7
3	Chemical analyses of surface water samples collected in 2006 from selected waters in the South Nahanni River watershed, Northwest Territories	8
4	Chemical analyses of surface water samples collected in 2006 from selected waters in the South Nahanni River watershed, Northwest Territories	9
5	Chemical analyses of surface water samples collected in 2007 from selected waters in the South Nahanni River watershed, Northwest Territories	10
6	Chemical analyses of surface water samples collected in 2007 from selected waters in the South Nahanni River watershed, Northwest Territories	11
7	Concentrations of trace elements in surface water samples collected in 2005 from selected waters in the South Nahanni River watershed, Northwest Territories	12
8	Concentrations of trace elements in surface water samples collected in 2005 from selected waters in the South Nahanni River watershed, Northwest Territories	13

Table		Page
9	Concentrations of trace elements in surface water samples collected in 2006 from selected waters in the South Nahanni River watershed, Northwest Territories	14
10	Concentrations of trace elements in surface water samples collected in 2006 from selected waters in the South Nahanni River watershed, Northwest Territories	15
11	Concentrations of trace elements in surface water samples collected in 2007 from selected waters in the South Nahanni River watershed, Northwest Territories	16

LIST OF FIGURES

Figure		
1	Map of the South Nahanni River watershed, Northwest Territories. Water sample collection sites are indicated by arrows and numbers	17

LIST OF APPENDICES

Appendix		
1	Detection limits, where available, for water chemistry parameters	18
2	Detection limits for individual trace element analysis	19

ABSTRACT

Babaluk, J.A., Tate, D.P., and Reist, J.D. 2009. Selected chemical analyses of waters from the South Nahanni River watershed, Northwest Territories. Can. Data Rep. Fish. Aquat. Sci. 1215: v + 19 p.

Selected chemical data collected between 2005 and 2007 from waters in the South Nahanni River watershed, Northwest Territories are tabulated.

Key words: chemical elements; streams survey; nutrients (mineral); trace elements; water analysis; water chemistry.

RÉSUMÉ

Babaluk, J.A., Tate, D.P., and Reist, J.D. 2009. Selected chemical analyses of waters from the South Nahanni River watershed, Northwest Territories. Can. Data Rep. Fish. Aquat. Sci. 1215: v + 19 p.

Présentation de données chimiques recueillies entre 2005 et 2007 des eaux du bassin versant de la rivière Nahanni Sud, dans les Territoires du Nord-Ouest.

Mots clés: éléments chimiques; enquête sur les cours d'eau; nutriments (minéraux); oligo-éléments; analyse de l'eau; composition chimique de l'eau.

INTRODUCTION

The distribution of fish species in the South Nahanni River watershed is not well known. The available literature concentrates on fish within Nahanni National Park Reserve (Wickstrom 1976; Wickstrom 1979; Mochnacz et al. 2002) and the two streams in the watershed that have mining developments located on them: Prairie Creek (Beak Consultants Limited 1981a; Beak Consultants Limited 1981b; Mochnacz et al. 2002) and Flat River (Sigma Resource Consultants Limited 1976; Moore et al. 1978). Between 2004-2007, Fisheries and Oceans Canada, in collaboration with Parks Canada, conducted fisheries surveys in the South Nahanni River watershed including Nahanni National Park Reserve. The aim of the work was to further document the distribution of fish species in the watershed and, in particular, document the distribution of Bull Trout, *Salvelinus confluentus*.

Opportunistically, while these fisheries surveys were conducted in the South Nahanni River watershed, water samples for chemical analysis were also collected. This report presents the chemical data from those water samples collected in the watershed between 2005-2007 and adds to the existing information on water chemistry for the watershed (e.g., Sergy 1973; Moore et al. 1978; Beavers 2002; Spencer et al. 2008) including Nahanni National Park Reserve (e.g., Wickstrom 1976; 1979; Wickstrom and Lutz 1981; Halliwell and Catto 1998).

MATERIALS AND METHODS

DESCRIPTION OF THE STUDY AREA

The South Nahanni River watershed encompasses an area of approximately 37 000 km^2 in the south-west corner of the Northwest Territories (Halliwell and Catto 1998) with its western edge laying on the border between the Northwest and Yukon territories (Figure 1). The headwaters of the South Nahanni River originate in The Moose Ponds area at the base of Mount Wilson (ca. 62° 55' N, 129° 40' W) and the river flows for approximately 550 km in a south-east direction roughly parallel to the NT/YT border before it empties into the Liard River near Nahanni Butte, NT (Halliwell and Catto 1998) (Figure 1). Virginia Falls, at ~90 m high, is located about two-thirds of the way down the South Nahanni River (Figure 1). Major inflowing streams to the South Nahanni above Virginia Falls include the Little Nahanni, Broken Skull, Sapper and Rabbitkettle rivers while those below the falls include the Flat River and Prairie Creek. Nahanni National Park Reserve currently

covers an area of 4 766 km^2 along the South Nahanni and Flat rivers (Figure 1). Nahanni National Park Reseve and the South Nahanni River watershed are described in detail in Parks Canada (1984) and by Halliwell and Catto (1998). For our study, the South Nahanni River watershed included only the streams flowing on the surface into the South Nahanni River. Some of the karst areas, where surficial waters flow in an adjacent watershed while subterranean waters flow into the South Nahanni River watershed, were not included.

WATER SAMPLING AND ANALYSIS

Water samples were collected from the following waters in the South Nahanni River watershed in 2005 (unnamed water bodies were usually assigned unofficial names by the authors based on nearby officially named topographic features): 1) Broken Skull River (62.80875° N, 128.02682° W); 2) Flat River above the mine at Tungsten, NT (62.01921° N, 128.30270° W); 3) Flat River below the mine at Tungsten (61.90736° N, 128.09800° W); 4) Funeral Creek (61.61033° N, 124.73540° W); 5) Little Nahanni River (62.15583° N, 128.56013° W); 6) Prairie Creek (61.74781° N, 124.94180° W); 7) Prairie Creek (61.70179° N, 124.90660° W); 8) Prairie Creek (61.60427° N, 124.83120° W); 9) Prairie Creek (61.54499° N, 124.77960° W); 10) an unnamed tributary of the South Nahanni River (62.45175° N, 128.54272° W); and 11) an unnamed tributary of the South Nahanni River (62.02308° N, 127.32910° W).

Water samples were collected from the following waters in the South Nahanni River watershed in 2006 (unnamed water bodies were usually assigned unofficial names by the authors based on nearby officially named topographic features or arbitrarily): 12) Bennett Creek (61.38049° N, 126.69707° W); 13) an unnamed stream, hereafter Black Shale Creek (61.51258° N, 125.43884° W); 14) an unnamed stream, hereafter Dolf Mountain Creek (61.97807° N, 127.23656° W); 15) Hole-in-the-Wall Creek (61.94482° N, 127.13124° W); 16) Lened Creek (62.37104° N, 128.68211° W); 17) Mac Creek (62.15549° N, 128.94214° W); 18) an unnamed stream, hereafter Osprey Creek (61.68009° N, 125.95799° W); 19) Prairie Creek (61.36413° N, 124.43630° W); 20) Sapper River (62.63107° N, 129.00295° W); 21) Secret Lake (61.97224° N, 127.04406° W); 22) South Nahanni River (62.80811° N, 129.51561° W); and 23) Steel Creek (62.38477° N, 128.91519° W).

Water samples were collected from the following waters in the South Nahanni River watershed in 2007 (unnamed water bodies were assigned unofficial names by the authors based on nearby officially named topographic features): 24) Dolf Mountain Creek (62.08793° N, 127.23307° W); 25) South Nahanni River (62.33805° N, 128.17788° W); and 26) South Nahanni River (61.89867° N,

126.98808° W).

All sampling locations are also shown in Fig. 1. The locations are indicated by numbers corresponding to the numbers listed above (1-26).

Water samples from the streams were collected in acid-washed polyethylene bottles by hand-dipping after wading out into the stream to a depth of ~1 m. The water sample from Secret Lake was collected from mid-lake by hand-dipping from a boat. All bottles were rinsed three times in ambient water before the sample was collected. Samples for dissolved element and nutrient analyses were refrigerated after collection and samples for trace element analyses were preserved in the field by addition of nitric acid. The samples were transported to Winnipeg, MB for subsequent analyses.

Water samples for dissolved element and nutrient analyses were analyzed at Fisheries and Oceans Canada's Freshwater Institute Analytical Water Chemistry Laboratory in Winnipeg following the procedures of Stainton et al. (1977). Estimates of precision for these procedures are given in Appendix 1 and Stainton et al. (1977). Trace elements were analyzed at Bodycote Testing Group Laboratory (formerly Norwest Labs) in Winnipeg by inductively coupled plasma mass spectrometry (ICP-MS) using commercial ICP standards and NRC standard reference materials. Detection limits are given in Appendix 2.

DATA PRESENTATION

Chemical data for South Nahanni River watershed waters collected in 2005 are presented in Tables 1, 2, 7, and 8; chemical data for South Nahanni River watershed waters collected in 2006 are presented in Tables 3, 4, 9, and 10 and; chemical data for South Nahanni River watershed waters collected in 2007 are presented in Tables 5, 6, and 11. All sampling locations have been assigned a location number (see location column in tables) that corresponds to the sample location numbers indicated in Fig. 1. In all tables, standard symbols are used to represent elements (Weast 1990). Other symbols and abbreviations used in the tables are as follows: SRSi = soluble reactive silicon, TSS = total suspended solids, SO_4 = sulphate, NO_3 = nitrate, NO_2 = nitrite, SN = suspended nitrogen, SP = suspended phosphorus, SC = suspended carbon, TDN = total dissolved nitrogen, TDP = total dissolved phosphorus, DIC = dissolved inorganic carbon, DOC = dissolved organic carbon, Cond. = conductivity, and Alk. = alkalinity.

ACKNOWLEDGMENTS

The work was done in large part with the support of Parks Canada. We thank George Betsaka, Dana Haggarty, Chantal Ouimet, Jennifer Redvers, Kim Schlosser, and Robert Vital for field assistance. Peter Andersen, Danny Ragan, Glen Sibbeston, and Andrew Steele piloted the helicopters required to access the sampling locations. Dana Haggarty, Chantelle Sawatzky, and Rick Wastle provided constructive comments on the manuscript.

REFERENCES

Beak Consultants Limited. 1981a. Prairie Creek project: fall fisheries study. Report prepared for Cadillac Explorations Ltd., Vancouver, BC. 35 p.

Beak Consultants Limited. 1981b. Prairie Creek project: fisheries and invertebrate studies. Report prepared for Cadillac Explorations Ltd., Vancouver, BC. 93 p.

Beavers, R. 2002. Historical water quality of the Prairie Creek Project area. Department of Indian Affairs and Northern Development, Water Resources Division, Yellowknife, NT. 47 p.

Halliwell, D., and Catto S. 1998. Protecting the aquatic quality of Nahanni National Park Reserve, N.W.T. Environment Canada, Yellowknife, NT. 102 p.

Mochnacz, N.J., Reist, J.D., and Tate, D.P. 2002. Bull trout (*Salvelinus confluentus*) distribution, life history, and habitat use in the South Nahanni watershed. Research Links 10: 18-21.

Moore, J.W., Hardin, M.J., and Sergy, G.A. 1978. The effects of metal mines on aquatic ecosystems in the Northwest Territories I. Canada Tungsten Mining Corporation Limited. Environmental Protection Service, Fisheries and Environment Canada, Report EPS 5-NW-78-8. 83 p.

Parks Canada. 1984. Nahanni National Park Reserve resource description and analysis. Natural Resource Conservation Section, Parks Canada, Prairie Region, Winnipeg, MB.

Sergy, G.A. 1973. A preliminary water quality investigation of the Flat River at Canada Tungsten,

Northwest Territories. Environment Canada, Environmental Protection Service Surveillance Report EPS NW-WP-73-2.

Sigma Resource Consultants Limited. 1976. Aquatic biology of the Flat River, NWT. Report prepared for Canada Tungsten Mining Corporation Ltd., Vancouver, BC. 76 p.

Spencer, P., Bowman, M.F., and Dubé, M.G. 2008. A multitrophic approach to monitoring the effects of metal mining on otherwise pristine and ecologically sensitive rivers in northern Canada. Integrated Environmental Assessment and Management 4: 327-343.

Stainton, M.P., Capel, M.J., and Armstrong, F.A.J. 1977. The chemical analysis of fresh water. 2nd ed. Canadian Fisheries and Marine Service Miscellaneous Special Publication 25: 166 p.

Weast, R.C. (ed.) 1990. Handbook of chemistry and physics. 70th edition. Boca Raton, Florida, CRC Press, Inc.

Wickstrom, R.D. 1976. Limnological survey of Nahanni National Park, 1975-1976: progress report. Prepared for Parks Canada by Canadian Wildlife Service, Winnipeg, MB. 35 p.

Wickstrom, R.D. 1979. Limnological survey of Nahanni National Park, N.W.T. 1978: progress report. Prepared for Parks Canada by Canadian Wildlife Service, Winnipeg, MB. 22 p.

Wickstrom, R.D., and Lutz, A. 1981. Tungsten and copper analysis of fish and sediments from the lower Flat River, Nahanni National Park, N.W.T. Canadian Wildlife Service Manuscript Report (no number), Winnipeg, MB. 34 p.

Table 1. Chemical analyses of surface water samples collected in 2005 from selected waters in the South Nahanni River watershed, Northwest Territories. Number in location column corresponds to sampling location indicated in Fig. 1.

Location	Map co-ordinates	Date collected	SRSi	Na	K	Ca	Mg	Fe	Mn	TSS	Cl	SO_4
			$mg\ L^{-1}$									
Broken Skull River (1)	62.80875°N 128.02682°W	25 Aug.	1.76	0.80	0.29	46.4	12.2	<0.01	<0.01	<1	0.31	32.08
Flat River (2)	62.01921°N 128.30270°W	23 Aug.	1.61	0.53	0.37	16.2	4.4	<0.01	<0.01	5	0.15	28.22
Flat River (3)	61.90736°N 128.09800°W	24 Aug.	2.09	1.31	0.56	26.6	6.2	<0.01	0.01	23	0.19	42.05
Funeral Creek (4)	61.61033°N 124.73540°W	21 Aug.	1.00	0.25	0.20	39.9	19.9	<0.01	0.01	<1	0.36	32.55
Little Nahanni River (5)	62.15583°N 128.56013°W	27 Aug.	1.85	0.64	0.31	24.5	6.7	<0.01	0.01	6	0.12	36.79
Prairie Creek (6)	61.74781°N 124.94180°W	22 Aug.	1.49	1.52	0.33	51.0	16.5	<0.01	0.01	<1	0.34	34.06
Prairie Creek (7)	61.70179°N 124.90660°W	22 Aug.	1.60	1.42	0.34	54.4	17.9	<0.01	0.01	<1	0.37	40.57
Prairie Creek (8)	61.60427°N 124.83120°W	21 Aug.	1.73	1.35	0.38	58.9	21.6	<0.01	0.01	<1	0.39	47.47
Prairie Creek (9)	61.54499°N 124.77960°W	22 Aug.	1.71	1.78	0.38	58.1	22.6	<0.01	<0.01	<1	0.42	51.61
South Nahanni R. trib. (10)	62.45175°N 128.54272°W	26 Aug.	1.58	0.34	0.28	41.1	15.8	<0.01	0.01	2	0.25	48.50
South Nahanni R. trib. (11)	62.02308°N 127.32910°W	26 Aug.	1.98	0.79	1.20	70.4	17.7	<0.01	0.01	6	0.22	99.80

Table 2. Chemical analyses of surface water samples collected in 2005 from selected waters in the South Nahanni River watershed, Northwest Territories. Precise sampling locations and collection dates are given in Table 1. Number in location column corresponds to sampling location indicated in Fig. 1.

Location	NO_3	NO_2	TDN	TDP	SN	SP	SC	DIC	DOC	Cond.	pH	Alk.
				$\mu g \cdot L^{-1}$				$\mu m \cdot L^{-1}$		$\mu S \cdot cm^{-1}$		$\mu eq \cdot L^{-1}$
Broken Skull River (1)	78	<1	117	2	5	2	310	2799	119	326	8.31	2680
Flat River (2)	8	<1	35	2	35	6	350	592	96	134	7.70	528
Flat River (3)	32	1	75	2	29	24	560	1022	59	201	7.77	930
Funeral Creek (4)	138	<1	168	2	<1	2	230	3066	119	345	8.28	2910
Little Nahanni River (5)	1	<1	44	2	22	10	400	985	91	192	7.84	924
Prairie Creek (6)	65	<1	117	2	<1	2	270	3309	138	374	8.33	3200
Prairie Creek (7)	75	<1	121	2	7	2	330	3381	166	398	8.37	3320
Prairie Creek (8)	102	<1	159	2	<1	2	260	3666	157	439	8.37	3640
Prairie Creek (9)	118	<1	163	2	<1	1	300	3696	175	453	8.35	3650
South Nahanni River tributary (10)	58	<1	97	2	45	4	410	2505	101	327	8.19	2320
South Nahanni River tributary (11)	43	<1	93	2	878	10	640	2841	110	486	8.24	2730

Table 3. Chemical analyses of surface water samples collected in 2006 from selected waters in the South Nahanni River watershed, Northwest Territories. Number in location column corresponds to sampling location indicated in Fig. 1.

Location	Map co-ordinates	Date collected	SRSi	Na	K	Ca	Mg	Fe	TSS	Cl	SO_4
			$mg \cdot L^{-1}$								
Bennett Creek (12)	61.38049°N 126.69707°W	25 Aug.	4.50	1.25	0.80	23.9	1.5	<0.01	1	0.05	5.35
Black Shale Creek (13)	61.51258°N 125.43884°W	25 Aug.	2.77	1.89	0.93	152.0	18.0	<0.01	1	0.91	226.16
Dolf Mountain Creek (14)	61.97807°N 127.23656°W	27 Aug.	1.81	0.75	0.69	52.7	17.3	<0.01	1	0.15	60.75
Hole-in-the-Wall Creek (15)	61.94482°N 127.13124°W	26 Aug.	2.87	1.61	0.72	17.2	3.8	0.04	1	0.10	17.91
Lened Creek (16)	62.37104°N 128.68211°W	28 Aug.	3.59	3.01	0.48	41.4	8.7	0.02	3	0.11	98.89
Mac Creek (17)	62.15549°N 128.94214°W	28 Aug.	2.08	0.71	0.20	23.4	1.4	0.02	<1	0.05	22.14
Osprey Creek (18)	61.68009°N 125.95799°W	25 Aug.	2.17	0.41	0.21	58.9	7.1	<0.01	<1	0.20	5.00
Prairie Creek (19)	61.36413°N 124.43630°W	24 Aug.	1.52	1.49	0.35	53.7	21.6	0.02	<1	0.41	58.17
Sapper River (20)	62.63107°N 129.00295°W	29 Aug.	2.72	0.92	0.30	22.9	6.2	<0.01	6	0.09	60.37
Secret Lake (21)	61.97224°N 127.04406°W	26 Aug.	1.50	0.24	0.35	40.7	13.3	0.02	<1	0.09	24.09
South Nahanni River (22)	62.80811°N 129.51561°W	29 Aug.	3.21	0.90	0.24	19.7	14.0	0.04	12	0.07	115.22
Steel Creek (23)	62.38477°N 128.91519°W	28 Aug.	2.24	0.88	0.40	34.6	7.1	<0.01	7	0.06	59.25

Table 4. Chemical analyses of surface water samples collected in 2006 from selected waters in the South Nahanni River watershed, Northwest Territories. Precise sampling locations and collection dates are given in Table 3. Number in location column corresponds to sampling location indicated in Fig. 1.

Location	NO_3	NO_2	TDN	TDP	SN	SC	DIC	DOC	Cond.	pH	Alk.
			$\mu g \cdot L^{-1}$				$\mu m \cdot L^{-1}$		$\mu S \cdot cm^{-1}$		$\mu eq \cdot L^{-1}$
Bennett Creek (12)	<1	<1	108	<1	26	240	1325	318	139	8.12	1172
Black Shale Creek (13)	68	1	197	1	24	180	4650	467	823	8.36	4290
Dolf Mountain Creek (14)	117	<1	149	<1	12	120	2945	106	395	8.37	2750
Hole-in-the-Wall Creek (15)	28	<1	89	1	14	170	881	133	131	7.92	796
Lened Creek (16)	29	<1	52	<1	22	280	845	60	311	7.90	769
Mac Creek (17)	8	<1	45	<1	10	100	962	83	144	7.96	860
Osprey Creek (18)	98	<1	199	2	19	190	3570	283	335	8.41	3310
Prairie Creek (19)	156	<1	186	<1	20	160	3310	102	421	8.35	3090
Sapper River (20)	42	<1	91	<1	54	690	551	139	191	7.60	521
Secret Lake (21)	190	1	223	2	22	170	2630	104	295	8.32	1170
South Nahanni River (22)	19	<1	58	<1	124	1820	33	114	272	4.80	-7
Steel Creek (23)	30	<1	69	<1	28	230	1272	86	248	8.06	1130

Table 5. Chemical analyses of surface water samples collected in 2007 from selected waters in the South Nahanni River watershed, Northwest Territories. Number in location column corresponds to sampling location indicated in Fig. 1.

Location	Map co-ordinates	Date collected	Na	K	Ca	Mg	TSS	Cl	SO_4
			$mg \cdot L^{-1}$						
Dolf Mountain Creek (24)	62.08793°N 127.23307°W	21 Aug.	0.42	0.60	36.80	11.00	<1	0.25	33.86
South Nahanni River at Island lakes (25)	62.33805°N 128.17788°W	22 Aug.	0.94	0.47	36.80	9.50	11	0.12	72.19
South Nahanni River at Secret lakes outlet (26)	61.89867°N 126.98808°W	22 Aug.	0.76	0.64	35.80	9.10	43	0.19	51.02

Table 6. Chemical analyses of surface water samples collected in 2007 from selected waters in the South Nahanni River watershed, Northwest Territories. Precise sampling locations and collection dates are given in Table 5. Number in location column corresponds to sampling location indicated in Fig. 1.

Location	NO_3	NO_2	TDN	TDP	SN	SC	DIC	DOC	Cond.	pH	Alk.
			$\mu g \cdot L^{-1}$				$\mu m \cdot L^{-1}$		$\mu S \cdot cm^{-1}$		$\mu eq \cdot L^{-1}$
Dolf Mountain Creek (24)	124	1	136	<1	15	260	2436	147	264	8.04	2137
South Nahanni River at Island lakes (25)	9	1	35	<1	40	500	1338	127	270	7.71	1181
South Nahanni River at Secret lakes outlet (26)	21	3	42	<1	72	2310	1854	123	263	7.78	1747

Table 7. Concentrations of trace elements in surface water samples collected in 2005 from selected waters in the South Nahanni River watershed, Northwest Territories. Precise sampling locations and dates are given in Table 1. Number in location cell corresponds to sampling location indicated in Fig. 1. All values in $mg \cdot L^{-1}$.

Element	Location				
	Broken Skull River (1)	Flat River (2)	Flat River (3)	Funeral Creek (4)	Little Nahanni River (5)
Aluminum (Al)	0.047	0.212	1.010	0.533	0.186
Antimony (Sb)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Arsenic (As)	0.0003	0.001	0.0023	0.0002	0.0013
Barium (Ba)	0.051	0.018	0.035	0.081	0.021
Beryllium (Be)	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Bismuth (Bi)	<0.0005	<0.0005	0.0007	<0.0005	<0.0005
Boron (B)	0.006	<0.002	0.009	0.004	0.003
Cadmium (Cd)	<0.00001	0.00001	0.00004	0.00003	0.00016
Calcium (Ca)	48.3	16.8	27.4	41.0	25.0
Chromium (Cr)	<0.0005	<0.0005	0.0012	<0.0005	<0.0005
Cobalt (Co)	<0.0001	0.0004	0.0022	<0.0001	0.0004
Copper (Cu)	0.002	<0.001	0.003	<0.001	<0.001
Iron (Fe)	<0.1	0.2	1.4	<0.1	0.3
Lead (Pb)	<0.0001	0.0002	0.0007	0.0001	0.0003
Lithium (Li)	0.002	0.002	0.010	0.001	0.003
Magnesium (Mg)	12.1	4.5	6.4	19.5	6.6
Manganese (Mn)	<0.005	0.012	0.034	<0.005	0.022
Molybdenum (Mo)	0.002	<0.001	<0.001	0.003	0.001
Nickel (Ni)	0.0017	0.0036	0.0107	0.0020	0.0046
Potassium (K)	<0.4	0.6	0.8	<0.4	<0.4
Selenium (Se)	0.0006	0.0002	0.0003	0.0007	0.0003
Silicon (Si)	1.75	1.81	3.40	0.99	2.03
Silver (Ag)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium (Na)	0.9	0.7	1.4	0.5	0.7
Strontium (Sr)	0.517	0.057	0.079	0.067	0.06
Sulfur (S)	12.6	10.9	15.5	12.6	14.2
Thallium (Tl)	<0.00005	<0.00005	<0.00005	0.00007	<0.00005
Tin (Sn)	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium (Ti)	0.0020	0.0059	0.0215	0.001	0.0037
Tungsten (W)	na	<0.005	<0.005	na	na
Uranium (U)	0.0018	<0.0005	0.0007	0.0028	0.0006
Vanadium (V)	0.0005	0.0004	0.0017	0.0008	0.0010
Zinc (Zn)	0.005	0.004	0.014	0.029	0.031
Zirconium (Zr)	<0.001	<0.001	<0.001	<0.001	<0.001

Table 8. Concentrations of trace elements in surface water samples collected in 2005 from selected waters in the South Nahanni River watershed, Northwest Territories. Precise sampling locations and dates are given in Table 1. Number in location cell corresponds to sampling location indicated in Fig. 1. All values in $mg \cdot L^{-1}$.

Element	Location					
	Prairie Creek (6)	Prairie Creek (7)	Prairie Creek (8)	Prairie Creek (9)	South Nahanni River tributary (10)	South Nahanni River tributary (11)
Aluminum (Al)	0.084	0.012	0.009	0.006	0.019	0.094
Antimony (Sb)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0008
Arsenic (As)	<0.0002	<0.0002	<0.0002	0.0003	0.0006	0.0012
Barium (Ba)	0.076	0.07	0.078	0.070	0.059	0.037
Beryllium (Be)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth (Bi)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron (B)	0.008	0.009	0.008	0.01	0.002	0.004
Cadmium (Cd)	<0.00001	<0.00001	<0.00001	<0.00001	0.00005	0.00035
Calcium (Ca)	50.7	54.9	58.3	58.8	42.5	72.4
Chromium (Cr)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Cobalt (Co)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper (Cu)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron (Fe)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lead (Pb)	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Lithium (Li)	0.002	0.002	0.002	0.003	0.001	0.003
Magnesium (Mg)	15.8	17.3	20.4	22.1	15.8	17.2
Manganese (Mn)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum (Mo)	0.003	0.004	0.004	0.004	<0.001	0.014
Nickel (Ni)	0.0007	0.0012	0.0015	0.0022	0.0018	0.0207
Potassium (K)	<0.4	0.4	<0.4	0.4	<0.4	1.2
Selenium (Se)	0.0008	0.001	0.0013	0.0010	0.0004	0.0037
Silicon (Si)	1.44	1.56	1.68	1.67	1.56	2.03
Silver (Ag)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium (Na)	1.6	1.5	1.4	1.9	<0.4	0.8
Strontium (Sr)	0.178	0.265	0.253	0.318	0.105	0.192
Sulfur (S)	13.2	16.0	18.3	20.4	17.0	38.1
Thallium (Tl)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Tin (Sn)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium (Ti)	0.0009	0.0011	0.0012	0.0011	0.0015	0.0058
Uranium (U)	0.0026	0.0036	0.0050	0.0046	0.0013	0.0096
Vanadium (V)	0.0006	0.0007	0.0006	0.0005	0.0002	0.0266
Zinc (Zn)	0.002	0.003	0.007	0.01	0.016	0.096
Zirconium (Zr)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 9. Concentrations of trace elements in surface water samples collected in 2006 from selected waters in the South Nahanni River watershed, Northwest Territories. Precise sampling locations and dates are given in Table 3. Number in location cell corresponds to sampling location indicated in Fig. 1. All values in $mg \cdot L^{-1}$.

Element	Location					
	Bennett Creek (12)	Black Shale Creek (13)	Dolf Mountain Creek (14)	Hole-in-the-Wall Creek (15)	Lened Creek (16)	Mac Creek (17)
Aluminum (Al)	0.052	0.117	0.020	0.096	0.806	0.017
Antimony (Sb)	<0.0002	0.0010	0.0002	<0.0002	<0.0002	<0.0002
Arsenic (As)	<0.0002	0.0005	0.0003	0.0008	0.0004	0.0005
Barium (Ba)	0.042	0.063	0.078	0.015	0.036	0.003
Beryllium (Be)	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001
Bismuth (Bi)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron (B)	0.003	0.019	0.004	0.007	0.026	<0.002
Cadmium (Cd)	<0.00001	0.00005	0.00002	0.00001	0.00024	<0.00001
Calcium (Ca)	24.0	154.0	53.1	17.6	42.4	24.3
Chromium (Cr)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Cobalt (Co)	<0.0001	0.0006	<0.0001	0.0008	0.0212	<0.0001
Copper (Cu)	<0.001	0.004	<0.001	0.003	0.008	<0.001
Iron (Fe)	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
Lead (Pb)	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Lithium (Li)	0.008	0.012	0.002	0.011	0.030	<0.001
Magnesium (Mg)	1.4	16.9	17.2	3.7	8.6	1.3
Manganese (Mn)	<0.005	<0.005	<0.005	0.007	0.231	<0.005
Molybdenum (Mo)	<0.001	0.043	0.002	<0.001	0.002	<0.001
Nickel (Ni)	0.0005	0.0515	0.0023	0.0090	0.0774	<0.0005
Potassium (K)	0.8	1.0	0.7	0.7	0.5	<0.4
Selenium (Se)	<0.0002	0.0051	0.0007	<0.0002	0.0009	<0.0002
Silicon (Si)	4.65	2.96	1.87	3.11	4.17	2.11
Silver (Ag)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium (Na)	1.2	1.9	0.7	1.6	3.2	0.7
Strontium (Sr)	0.085	0.674	0.169	0.063	0.090	0.128
Sulfur (S)	1.6	74.0	19.8	6.2	33.7	7.0
Thallium (Tl)	<0.00005	0.0001	<0.00005	<0.00005	<0.00005	<0.00005
Tin (Sn)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium (Ti)	0.0018	0.0045	0.0018	0.0022	0.0017	0.0005
Uranium (U)	0.0027	0.0301	0.0049	0.0011	0.0020	0.0006
Vanadium (V)	0.0004	0.0010	0.0002	0.0004	0.0008	<0.0001
Zinc (Zn)	0.002	0.079	0.008	0.023	0.070	<0.001
Zirconium (Zr)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 10. Concentrations of trace elements in surface water samples collected in 2006 from selected waters in the South Nahanni River watershed, Northwest Territories. Precise sampling locations and dates are given in Table 3. Number in location cell corresponds to sampling location indicated in Fig. 1. All values in $mg \cdot L^{-1}$.

Element	Location					
	Osprey Creek (18)	Prairie Creek (19)	Sapper River (20)	Secret Lake (21)	South Nahanni River (22)	Steel Creek (23)
Aluminum (Al)	0.034	0.014	1.52	0.005	3.14	0.281
Antimony (Sb)	<0.0002	<0.0002	<0.0002	0.0003	<0.0002	<0.0002
Arsenic (As)	0.0003	<0.0002	0.0009	0.0004	0.0003	0.0003
Barium (Ba)	0.036	0.068	0.022	0.135	0.040	0.022
Beryllium (Be)	<0.0001	<0.0001	0.0001	<0.0001	0.0003	<0.0001
Bismuth (Bi)	<0.0005	0.0008	<0.0005	<0.0005	<0.0005	<0.0005
Boron (B)	0.002	0.009	0.011	0.002	0.003	<0.002
Cadmium (Cd)	<0.00001	<0.00001	0.00101	<0.00001	0.00192	0.00056
Calcium (Ca)	61.5	53.2	23.4	40.4	20.1	35.8
Chromium (Cr)	<0.0005	<0.0005	<0.0005	<0.0005	0.0005	<0.0005
Cobalt (Co)	<0.0001	<0.0001	0.0106	<0.0001	0.0216	0.0037
Copper (Cu)	0.001	0.002	0.005	<0.001	0.025	0.002
Iron (Fe)	<0.1	<0.1	0.3	<0.1	1.1	<0.1
Lead (Pb)	<0.0001	<0.0001	0.0001	<0.0001	0.0002	0.0002
Lithium (Li)	0.002	0.003	0.012	<0.001	0.019	0.005
Magnesium (Mg)	6.8	21.2	6.0	13.4	13.7	6.8
Manganese (Mn)	<0.005	0.027	0.088	<0.005	0.579	0.045
Molybdenum (Mo)	<0.001	0.003	<0.001	<0.001	<0.001	<0.001
Nickel (Ni)	<0.0005	0.0009	0.0470	<0.0005	0.116	0.0207
Potassium (K)	<0.4	<0.4	<0.4	<0.4	<0.4	0.4
Selenium (Se)	<0.0002	0.001	0.0006	<0.0002	0.0009	0.0006
Silicon (Si)	2.26	1.58	3.46	1.49	3.79	2.44
Silver (Ag)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium (Na)	<0.4	1.5	0.9	<0.4	0.8	0.8
Strontium (Sr)	0.128	0.240	0.105	0.052	0.110	0.159
Sulfur (S)	1.6	19.2	18.6	8.1	38.3	18.9
Thallium (Tl)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Tin (Sn)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium (Ti)	0.0011	0.0011	0.0033	0.0005	0.0034	0.0012
Uranium (U)	0.0006	0.0049	0.0018	0.0006	0.0008	0.0012
Vanadium (V)	0.0003	0.0004	0.0005	<0.0001	0.0004	0.0001
Zinc (Zn)	<0.001	0.004	0.137	<0.001	0.315	0.066
Zirconium (Zr)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 11. Concentrations of trace elements in surface water samples collected in 2007 from selected waters in the South Nahanni River watershed, Northwest Territories. Precise sampling locations and dates are given in Table 5. Number in location cell corresponds to sampling location indicated in Fig. 1. All values in $mg \cdot L^{-1}$.

Element	Location		
	Dolf Mountain Creek (24)	South Nahanni River at Island lakes (25)	South Nahanni River at Secret lakes outlet (26)
Aluminum (Al)	0.059	1.090	2.650
Antimony (Sb)	<0.0002	<0.0002	0.0002
Arsenic (As)	0.0008	0.001	0.0028
Barium (Ba)	0.055	0.044	0.090
Beryllium (Be)	<0.0001	0.0001	0.0001
Bismuth (Bi)	<0.0005	<0.0005	<0.0005
Boron (B)	<0.002	0.005	0.007
Cadmium (Cd)	0.00005	0.00069	0.00038
Calcium (Ca)	37.3	35.9	44.3
Chromium (Cr)	<0.0005	0.0006	0.0030
Cobalt (Co)	<0.0001	0.0064	0.0031
Copper (Cu)	<0.001	0.004	0.003
Iron (Fe)	<0.1	0.6	2.3
Lead (Pb)	<0.0001	0.0003	0.0016
Lithium (Li)	0.002	0.011	0.011
Magnesium (Mg)	11.4	9.6	10.4
Manganese (Mn)	<0.005	0.104	0.058
Molybdenum (Mo)	0.001	<0.001	0.002
Nickel (Ni)	0.0014	0.0356	0.0171
Potassium (K)	0.6	0.6	1.5
Selenium (Se)	0.0002	0.0003	0.0007
Silicon (Si)	1.53	3.09	6.21
Silver (Ag)	<0.0001	<0.0001	<0.0001
Sodium (Na)	0.5	1.0	0.9
Strontium (Sr)	0.129	0.134	0.182
Sulfur (S)	11.5	23.7	16.5
Thallium (Tl)	<0.00005	<0.00005	<0.00005
Tin (Sn)	<0.001	<0.001	<0.001
Titanium (Ti)	<0.0005	0.0160	0.0856
Uranium (U)	0.0025	0.0012	0.0020
Vanadium (V)	0.0003	0.0011	0.0070
Zinc (Zn)	0.004	0.092	0.046
Zirconium (Zr)	<0.001	<0.001	0.002

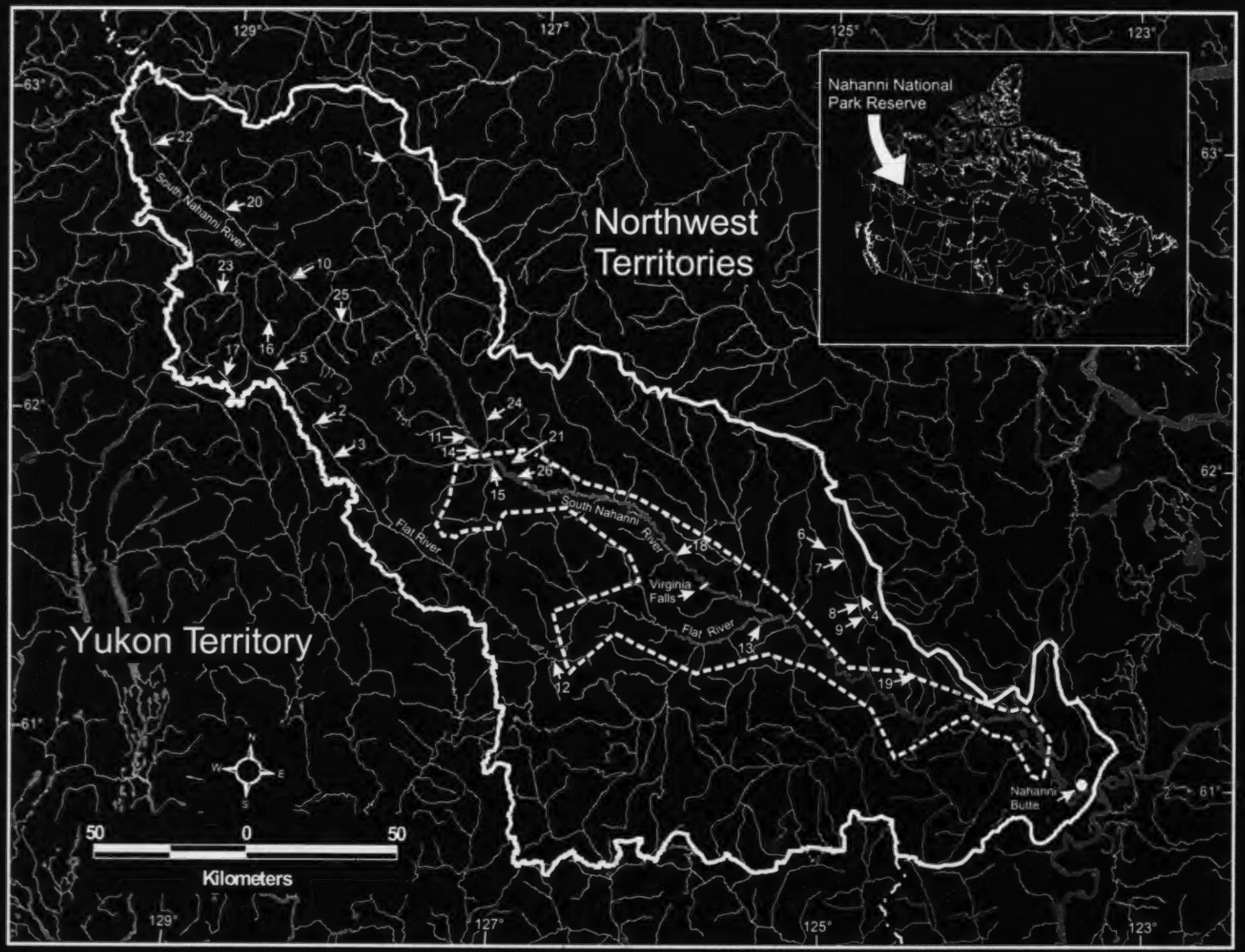

Figure 1. Map of the South Nahanni River watershed, Northwest Territories. Watershed boundary is indicated by a solid line. Watershed does not include karst areas. Nahanni National Park Reserve is indicated by a broken line. Water sample collection sites are indicated by arrows and numbers.

Appendix 1. Detection limits, where available, for water chemistry parameters as provided by the Freshwater Institute Analytical Water Chemistry Laboratory in Winnipeg, MB (C. Anema, pers. comm. 2008).

Parameter	Detection limit	Units
NO_3	0.8	$\mu g \cdot L^{-1}$
NO_2	0.6	$\mu g \cdot L^{-1}$
SN	0.15	$\mu g \cdot L^{-1}$
TDN	9	$\mu g \cdot L^{-1}$
TDP	1	$\mu g \cdot L^{-1}$
DIC	29	$\mu m \cdot L^{-1}$
DOC	9.5	$\mu m \cdot L^{-1}$
SC	1	$\mu g \cdot L^{-1}$
SP	na	na
Alk	na	$\mu eq \cdot L^{-1}$
SRSi	na	$mg \cdot L^{-1}$
Cl	0.05	$mg \cdot L^{-1}$
SO_4	0.03	$mg \cdot L^{-1}$
TSS	0.1	$mg \cdot L^{-1}$
Cond.	1.2	$\mu S \cdot cm^{-1}$
Na	0.01	$mg \cdot L^{-1}$
K	0.01	$mg \cdot L^{-1}$
Mg	0.001	$mg \cdot L^{-1}$
Mn	na	na
Ca	0.045	$mg \cdot L^{-1}$
Fe	na	$mg \cdot L^{-1}$
pH	na	na

Appendix 2. Detection limits for individual trace element analysis (inductively-coupled plasma mass spectrometry method) as provided by Bodycote Testing Group (formerly Norwest Labs), Winnipeg, MB. All values in $mg \cdot L^{-1}$.

Element	Analysis Year		
	2005	2006	2007
Aluminum (Al)	0.005	0.005	0.005
Antimony (Sb)	0.0002	0.0002	0.0002
Arsenic (As)	0.0002	0.0002	0.0002
Barium (Ba)	0.001	0.001	0.001
Beryllium (Be)	0.0001	0.0001	0.0001
Bismuth (Bi)	0.0005	0.0005	0.0005
Boron (B)	0.002	0.002	0.002
Cadmium (Cd)	0.0001	0.00001	0.00001
Calcium (Ca)	0.2	0.2	0.2
Chromium (Cr)	0.0005	0.0005	0.0005
Cobalt (Co)	0.0001	0.0001	0.0001
Copper (Cu)	0.001	0.001	0.001
Iron (Fe)	0.1	0.1	0.1
Lead (Pb)	0.0001	0.0001	0.0001
Lithium (Li)	0.001	0.001	0.001
Magnesium (Mg)	0.1	0.1	0.1
Manganese (Mn)	0.005	0.005	0.005
Molybdenum (Mo)	0.001	0.001	0.001
Nickel (Ni)	0.0005	0.0005	0.0005
Potassium (K)	0.4	0.4	0.4
Selenium (Se)	0.0005	0.0002	0.0002
Silicon (Si)	0.05	0.05	0.05
Silver (Ag)	0.0001	0.0001	0.00001
Sodium (Na)	0.4	0.4	0.4
Strontium (Sr)	0.001	0.001	0.001
Sulfur (S)	0.3	0.3	0.3
Thallium (Tl)	0.00005	0.00005	0.00005
Tin (Sn)	0.001	0.001	0.001
Titanium (Ti)	0.0005	0.0005	0.0005
Tungsten (W)	0.0005	na	na
Uranium (U)	0.0005	0.0005	0.0005
Vanadium (V)	0.0001	0.0001	0.0001
Zinc (Zn)	0.001	0.001	0.001
Zirconium (Zr)	0.001	0.001	0.001